Skin Temperature Perturbations Induced by Surface Layer Turbulence

by

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Submitted to:	Water Resources Research
Date Submitted:	

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Abstract

High frequency (5 Hz) atmospheric surface layer (ASL) turbulent velocity (u') and infrared skin temperature perturbations (T_s') were measured above a grass-covered forest clearing and analyzed for cloud free conditions. These measurements were used to investigate mechanisms responsible for the production of large short-lived T_s' perturbations caused by rapid excursions in u'. To quantify the effects of u' on rapid surface cooling, wavelet spectra of u' and T_s' and co-spectra of $u'T_s'$ were computed. The u' wavelet power spectra were then analyzed using Townsend's (1976) hypothesis. Townsend's hypothesis states that ASL eddy motion can be decomposed into an active component, which is a function of the ground shear stress (u_*) and height (z) above the zero plane displacement, and an inactive component, which is produced in the atmospheric boundary layer (ABL) outer region. A -1 power-law in the u' power spectrum was used as a signature for inactive eddy motion. Therefore, the -1 power-law was used to identify wavenumber ranges (about 1.5 decades) associated with inactive eddy motion. The measured T_s' wavelet spectra and $u'T_s'$ co-spectra identified with this wavenumber range demonstrate that much of the T_s' energy and $\langle u'T_s' \rangle$ are due to inactive eddy motion, where $\langle . \rangle$ is time averaging. Hence, in contrast to the laboratory experiments of Owen and Thomson (1963), it is argued that skin temperature perturbations at the canopy-atmosphere interface of a grass-covered surface (small thermal inertia) are strongly dependent on the inactive eddy motion produced in the outer layer of the ABL.